

Pedestrian Signal Safety for Older Persons



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LIST OF ABBREVIATIONS

Access Board	Architectural and Transportation Barriers Compliance Board
ADPV	average delay per vehicle
AVD	average vehicle delay
CORSIM	CORridor SIMulation
DW	DON'T WALK interval
FDW	flashing DON'T WALK interval
FHWA	Federal Highway Administration
G/C	green time to cycle length ratio
ITE	Institute of Transportation Engineers
LOS	level of service
LPI	leading pedestrian interval
MnDOT	Minnesota Department of Transportation
MOE	measure of effectiveness
MUTCD	<i>Manual on Uniform Traffic Control Devices</i>
MWS	mean walking speed
NCUTCD	National Committee on Uniform Traffic Control Devices
PATH	Portable Archival Traffic History
PCD	pedestrian countdown
PCI	pedestrian clearance interval
PCT	pedestrian clearance time
TAC	Transportation Association of Canada
TPS	traditional pedestrian signals
TRIS	Transportation Research Information Service
W	WALK interval

LIST OF DEFINITIONS

Access Board

The Access Board is an independent federal agency devoted to accessibility for people with disabilities. Created in 1973 to ensure access to federally funded facilities, the Access Board is now a leading source of information on accessible design. The Access Board develops and maintains design criteria for the built environment, transit vehicles, telecommunications equipment, and electronic and information technology. It also provides technical assistance and training on these requirements and on accessible design and continues to enforce accessibility standards that cover federally funded facilities.

Available Green Time

The available green time is the maximum time that can be allotted to the pedestrian signal interval based on existing signal timings and phasing. The available green represents the green intervals for the parallel streets. Available green times do not add up to the cycle length because of time allotted to exclusive phasing for turn movements, concurrent phasing for approaches on the same street (for example, northbound and southbound approaches), and yellow and red intervals.

Cycle Length

Cycle length is the time required to complete one sequence of signal indications (see *Manual on Uniform Traffic Control Devices for Streets and Highways, 2003 Edition*. 2003. Washington, DC: U.S. Department of Transportation).

Green Time to Cycle Length Ratio

The G/C ratio is the proportion of green time available for all traffic movements (other non-concurrent movements) after the pedestrian phase for a single crossing has been determined based on a given walking speed, cycle length, and crossing distance. Higher G/C ratios permit higher vehicle throughput and, many times, less time for pedestrians to cross a street. Conversely, lower G/C ratios permit lower vehicle throughput and, potentially, more pedestrian crossing time—many times with tradeoffs in vehicular intersection efficiency.

Interval

The interval is the part of a signal cycle during which the signal indications do not change (see *Manual on Uniform Traffic Control Devices for Streets and Highways, 2003 Edition*. 2003. Washington, DC: U.S. Department of Transportation).

Leading Pedestrian Interval

A leading pedestrian interval is equipment or new timing installed at signalized intersections to release pedestrian traffic in advance of turning vehicles for signals with protected left-turn movements or all movements for permitted left-turn movements. The WALK indication or WALKING PERSON symbol is displayed in advance of the green signal indication for vehicles (see Zegeer, C.V. et al. 2001. *Pedestrian Facilities Users Guide—Providing Safety and Mobility*. FHWA-RD-01-102. McLean, Virginia: Federal Highway Administration; Staplin, L., S. Lococo, S. Byington, and D. Harkey. 2001. *Guidelines and Recommendations to Accommodate Older Drivers and Pedestrians*. FHWA-RD-01-051. McLean, Virginia: Federal Highway Administration; and Van Houten, R., R.A. Retting, C.M. Farmer, and J. Van Houten. 2000. Field evaluation of a leading pedestrian interval signal phase at three urban intersections. *Transportation Research Record* 1734).

Level of Service

LOS is a qualitative measure used to describe the operational condition of an intersection. LOS utilizes a rating system ranging from A to F, with A signifying the highest LOS, characterized by insignificant vehicular delay, and F signifying the lowest LOS, characterized by excessive vehicular delay. By definition, an intersection operating at its capacity is operating at LOS E.

National Committee on Uniform Traffic Control Devices

NCUTCD, or the National Committee, is an organization whose purpose is to assist in the development of standards, guides, and warrants for traffic control devices and practices used to regulate, warn, and guide traffic on streets and highways. NCUTCD recommends to the Federal Highway Administration (FHWA) and other appropriate agencies proposed revisions to and interpretations of the *Manual on Uniform Traffic Control Devices* (MUTCD) and other accepted national standards. NCUTCD develops public and professional awareness of the principles of safe traffic control devices and practices and provides a forum for qualified individuals with diverse backgrounds and viewpoints to exchange professional information.

Pedestrian Change Interval

An interval in which the flashing UPRAISED HAND (symbolizing DON'T WALK) signal indication is displayed. When a verbal message is provided at an accessible pedestrian signal, the verbal message is "wait" (see *Manual on Uniform Traffic Control Devices for Streets and Highways, 2003 Edition*. 2003. Washington, DC: U.S. Department of Transportation).

Pedestrian Clearance Time

PCT is the time provided for a pedestrian crossing in a crosswalk, after leaving the curb or shoulder, to travel to the far side of the traveled way or to a median. PCT is calculated by taking the length of the crosswalk and dividing it by the crossing speed.

Transportation Association of Canada

The Transportation Association of Canada is a national association with a mission to promote the provision of safe, secure, efficient, effective, and environmentally and financially sustainable transportation services in support of Canada's social and economic goals.

FOREWORD

ABOUT THE SPONSOR

This study was funded by the AAA Foundation for Traffic Safety in Washington, DC. Founded in 1947, the AAA Foundation is a not-for-profit, publicly supported charitable research and education organization dedicated to saving lives by preventing traffic crashes and reducing injuries when crashes occur. Funding for this report was provided by voluntary contributions from AAA/CAA and their affiliated motor clubs, from individual members, from AAA-affiliated insurance companies, as well as from other organizations and sources.

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INTRODUCTION

This summary report is based on the companion technical report entitled *Pedestrian Signal Safety for Older Persons*. The technical report includes the following major sections and appendices:

- Executive Summary
- Introduction
- Methods
- Results
- Discussion
- References
- Appendix A: Pedestrian Countdown Signal Survey: Instrument and Findings
- Appendix B: Pedestrian Observation Survey Instrument
- Appendix C: Broward County, Florida Case Study
- Appendix D: Minneapolis, Minnesota Case Study
- Appendix E: Montgomery County, Maryland Case Study
- Appendix F: White Plains, New York Case Study
- Appendix G: Salt Lake City, Utah Case Study
- Appendix H: Orange County, California Case Study
- Appendix I: Monroe County, New York Criteria for Deployment of Pedestrian Countdown Devices
- Appendix J: National Committee on Uniform Traffic Control Devices Revisions to Walking Speeds Section 4E.10

To obtain an electronic copy of the full technical report, please visit the AAA Foundation for Traffic Safety Web site at www.aaafoundation.org.

The technical report is intended to assist practitioners and researchers in the transportation profession in gaining a comprehensive understanding of the nuances of walking speeds and other pedestrian characteristics of older persons, including behavior at traditional and pedestrian countdown signals. This summary report is intended to convey the findings and conclusions of the study to management, elected officials, and the general public in an easily understandable format.

The completion, timing, and technical findings of this study are in line with a number of external events that may assist in the implementation of differential (lower) walking speeds at intersections where there are a significant number of older persons. The following pertinent external events have taken place in the past 18 months:

- The National Committee on Uniform Traffic Control Devices (NCUTCD) voted unanimously at its January 20, 2006 meeting to support changes to the *Manual on Uniform Traffic Control Devices* (MUTCD) Section 4.E.10 (Walking Speeds). (See Table 9 on page 41 for specific recommendations).
- The Architectural and Transportation Barriers Compliance Board (Access Board) set forth a Notice of Availability of Draft Guidelines for Accessibility within the Public Rights-of-Way on November 23, 2005. One element of the draft guidelines relates to pedestrian walking speeds. Section R305.3, entitled "Pedestrian Signal Phase Timing," indicates that "all pedestrian signal phase timing shall be calculated using a pedestrian walking speed of 3.5 ft./sec. maximum. The crossing distance used in calculating pedestrian phase signal timing shall include the entire length of the crosswalk."
- The U.S. Department of Transportation (U.S. DOT) Federal Highway Administration (FHWA) released a memorandum dated January 23, 2006 (see Appendix K of the Technical Report) that informs public agencies and the general public of the availability of the Draft Guidelines for Accessibility within the Public Rights-of-Way and discusses the interim status of the guidelines until such time that they are adopted by the Justice Department and U.S. DOT.
- It is anticipated that FHWA will issue a Notice of Proposed Amendments to various MUTCD sections that could be included in the Federal Register by the summer of 2007. This would be followed by a comment period.
- U.S. DOT will review all comments and make a decision to accept, modify, or reject the NCUTCD recommendations as it goes forward with issuing the next edition of MUTCD, which is currently scheduled for 2009.

BACKGROUND

Three major trends contribute to the need for better understanding and better design of traffic signals for older pedestrians: 1) the aging population; 2) the desire to make communities more livable and walkable; and 3) the number of pedestrian injuries and fatalities.

Increasingly, citizens are petitioning community leaders and transportation professionals to make communities more walkable. In the United States, the proportion of the population over age 65 is expected to increase from 12.4 percent (approximately 30 million) in 2000 to approximately 20 percent (an estimated 71.5 million) in 2030 (Federal Interagency Forum on Aging-Related Statistics).

In 2004, 4,641 pedestrians were killed in motor vehicle crashes. Of this number, 939 pedestrians (20 percent) were age 65 or older. Of the 939 older pedestrians killed, 80 percent were age 70 or older (Traffic Safety Facts 2004 Data, Pedestrians).

The expected population increase in people age 65 and older will likely be accompanied by an increase in highway injuries and fatalities for the same age group if the transportation community is not able to lower the risks faced by older road users, including older pedestrians.

Because of these trends, traffic engineers must respond with better designed intersections and traffic signals that are timed to meet the needs of all pedestrians and vehicles. At many signalized intersections, pedestrian signals are used to provide pedestrians with a prescribed period of time during which they can cross the road. This is accomplished either through an exclusive pedestrian phase or concurrently with parallel traffic.

The timing of the pedestrian clearance interval (PCI)—when flashing DON'T WALK (FDW) is displayed—is based on pedestrian walking speed and crossing distance. The *Manual on Uniform Traffic Control Devices* (MUTCD) prescribes 4.00 feet/second (ft./sec.) as a walking speed, with the allowance for a slower speed where there are users who are not capable of walking at that speed, such as older pedestrians (Federal Highway Administration 2003). The current edition of MUTCD provides the following guidance:

The pedestrian clearance time should be sufficient to allow a pedestrian crossing in the crosswalk who left the curb or shoulder during the WALKING PERSON (symbolizing WALK) signal indication to travel at a walking speed of 1.2 m (4 ft.) per second, to at least the far side of the traveled way or to a median of sufficient width for pedestrians to wait. Where pedestrians who walk slower than 1.2 m (4 ft.) per second, or pedestrians who use wheelchairs, routinely use the crosswalk, a walking speed of less than 1.2 m (4 ft.) per second should be considered in determining the pedestrian clearance time.

WHY IS PEDESTRIAN WALKING SPEED SO IMPORTANT FROM AN OLDER PERSON'S PERSPECTIVE?

The Web site www.walkinginfo.org features an article entitled "The Design Needs of Senior Pedestrians," by Rebecca Johnson, which states: "Even the smallest design and engineering improvements can make a big difference... and for senior pedestrians... they can mean the difference between walking safely and confidently across the street—or waiting in traffic." (Pedestrian and Bicycle Information Center)

The walking speed set for signal operations is by far one of the most important design and operational parameters that can affect pedestrian-vehicular conflicts, pedestrian safety, and crashes at signalized intersections. All pedestrians and, in particular, those who are older or mobility-impaired, need to be provided with adequate time to cross the street safely and need to know that they have sufficient time to cross.

The current study and many previous studies suggest that there is at least a 0.70-ft./sec. walking speed difference between older and younger persons.

Figure 1 illustrates how important establishing adequate signal timing for pedestrians can be. This figure shows a 70-ft. street crossing from point A to point B. Given that older and younger pedestrians walk at different speeds, where will the older pedestrian be when his/her younger counterpart reaches the far curb?

Assuming that the younger pedestrian walks at 4.00 ft./sec. (the speed prescribed by the current edition of MUTCD) and the older pedestrian walks 0.70 ft./sec. slower, the older pedestrian would have more than 12 ft. to walk—or another whole lane to cross—when the younger pedestrian had successfully crossed the street.



Figure 1. Senior Showcase Driver Roadway in Detroit, Michigan. Presentation to the North American Conference on Elderly Mobility, September 12, 2004. Source: Kimberly Lariviere. Photo overlay: Edward Stollof.

Note: Map not to scale.

STUDY OBJECTIVES

This study had two primary objectives: 1) to provide the supporting research to assist traffic engineers in understanding the walking characteristics of older pedestrians and 2) to provide more information on the extent to which various intersection operational conditions might be able to tolerate additional time for the pedestrian interval without sacrificing substantial efficiencies (and, conversely, the identification of intersection operational conditions that would provide significant degradation in the movement of vehicles).

This project addressed both objectives by answering the following questions:

- What are the walking speeds of pedestrians when crossing under signal control?
- How does walking speed differ with respect to age?
- Do pedestrians understand pedestrian countdown (PCD) signals? Do they prefer PCD signals or traditional pedestrian signals (TPS)?
- What are the impacts of countdown signals on pedestrian behavior and walking speed?
- How does the amount of time allocated for pedestrian intervals affect traffic operations such as vehicle delay?

Note: Older persons were defined in this study as individuals age 65 and older. Younger persons were defined as individuals under age 65. Many studies define older and younger persons differently.

STUDY LIMITATIONS

Comparability of Intersections

This study employed a cross-sectional design instead of a potentially more robust before-and-after design. The assumption in this cross-sectional design was that differences in pedestrian behavior observed at the two intersections can be attributed to the difference in pedestrian signals.

Although similar, the intersections were different in some respects that could affect pedestrian behavior, confounding the relationship between pedestrian signals and behavior. The comparison also assumed that the same pedestrian populations were present at both sets of intersections. The project team attempted to select study intersections in close proximity to one another to minimize this concern.

Weather

Pedestrians are likely to change their behavior during cold or otherwise unpleasant weather. The project team attempted to collect the pedestrian behavior data during periods of dry, clear, warm weather; however, this was not always possible.

Survey Response Rate

The pedestrian survey response rates were much lower than expected during the on-street intercept survey, particularly for older pedestrians. Because the survey was voluntary with no incentives, the responses may have been skewed toward those pedestrians who were concerned enough with intersection safety to respond to the survey and possibly were less “fearful” of strangers.

Visual Determination of Age

The pedestrian behavior results were examined separately for pedestrians under 65 and pedestrians 65 and older. The determination of a pedestrian’s age was made based on visual inspection only. Trained observers were used to collect the data. The observers were trained to be consistent in looking at physical attributes such as hair color, posture, and skin features to determine age. The cameras were positioned to provide a close-up view of each pedestrian as he/she crossed the intersection. Only one observer was assigned to each intersection and he/she tried to be consistent in determining age. A project engineer oversaw quality control and was available to provide guidance in the determination of the age of individual pedestrians.

Self Selection

The walking speed measurements were based on samples of pedestrians crossing at the study intersections. This study did not examine walking speeds of pedestrians who would have liked to cross at the study intersections but were not able. It is possible that some pedestrians with slower walking speeds sought alternate routes or alternate transportation modes because they were not able to cross at the study intersections given the available time.

Persons with Disabilities

This study included measurements of start-up time and walking speed for persons with vision, cognitive, or mobility impairments that the research team could discern by visual inspection. These data are not included in this summary report but are included in the accompanying technical report. Due to the small number of pedestrians with discernible disabilities observed in this study and/or possible misclassification of individuals, this report’s recommendations may not be appropriate for accommodating persons with disabilities.

Applicability to Other Intersections

This study was based on samples of pedestrians from 23 intersections in six jurisdictions around the United States. This report presents information on the characteristics of younger and older pedestrians at those intersections. It is unlikely that the samples were representative of all pedestrian populations at all intersections in the United States. Many aspects of a single intersection or jurisdiction may affect the walking characteristics of pedestrians, including traffic volumes, approach grades, temperature, and surrounding land use. The project team attempted to identify jurisdictions that were geographically dispersed and diverse.

METHODS

The project objectives were accomplished through the following activities.

LITERATURE REVIEW

To provide background information on safely accommodating older pedestrians at intersections, recently published literature (within the last 20 years) was reviewed on topics including the pedestrian walking task, pedestrian signal timing (especially as it relates to the needs of older pedestrians), pedestrian walking speed, and pedestrian countdown (PCD) signals. This literature was identified through searching the Transportation Research Information Service and the Internet.

WEB-BASED AGENCY SURVEY

The project team conducted a Web-based survey of governmental organizations in June 2004 to identify the state of the art and state of the practice in pedestrian signal timing and the use of pedestrian signals. The project team also requested information regarding PCD signals, including pedestrian comprehension of traditional and countdown signals, number of countdown signals, advantages, and challenges. A copy of the survey instrument is included in Appendix A of the technical report.

OBSERVATIONAL STUDY OF PEDESTRIANS

An observational study of pedestrians was completed between September 2004 and March 2005 using a Portable Archival Traffic History (PATH) video system to obtain data on walking speeds, pedestrian start-up time, and signal compliance. Each PATH video system consists of a recording package and a camera enclosure. The recording package includes a time-lapse VCR and a power source. It is housed in weatherproof aluminum housing, as shown in Figure 2. The camera systems are less conspicuous than observers in the field.

Depending on the type of recording and the view needed, one or more cameras were mounted above the recording enclosure. Field deployment of a camera is shown in Figure 3. The project team installed the PATH system at each study intersection, with the exception of intersections in Orange County, California. The PATH system is used extensively in the conduct of pedestrian studies in peer-reviewed research.



Figure 2. Portable Archival Traffic History (PATH) camera video system.



Figure 3: Field deployment of the PATH camera video system.

The criteria for selecting jurisdictions where the observational studies would be conducted included having both traditional and PCD signals; a large proportion of seniors in the population; agencies that were willing to cooperate; and jurisdictions from various regions of the country. In addition, the project team also ensured that the PCD signals installed in the jurisdiction were compliant with the current edition of MUTCD (for example, the countdown is only displayed during the flashing DON'T WALK at these intersections).

Using the information collected, the following jurisdictions were selected for the study:

- Broward County, Florida
- Minneapolis, Minnesota
- Montgomery County, Maryland
- White Plains, New York
- Salt Lake City, Utah
- Orange County, California

Detailed data and results from individual jurisdictions are presented in Appendices C–H, respective of the accompanying technical report (AAA Foundation for Traffic Safety 2007)

In each of the six jurisdictions, the project team worked with the local engineering staff and local AAA representative(s) to select four intersections to be used in the study—two intersections equipped with PCD signals and two intersections equipped with traditional pedestrian signals (TPS). One of the four intersections also was selected to be a case study intersection, which was used in the intersection operations analysis.

PEDESTRIAN BEHAVIOR DATA COLLECTION

For most intersections (except where sample size requirements dictated more data), the PATH system was set to record peak pedestrian and vehicle activity, usually from 7:00 a.m. to 7:00 p.m. for one minor leg and one major leg for one day. As shown in Table 1, the total number of pedestrian observations for both TPS and PCD signals was 4,152. Of this number, 1,437 (or approximately 35 percent) were older pedestrians, as defined in this study (age 65 or older).

The tape recordings were used to obtain pedestrian start-up times, pedestrian walking speeds, and pedestrian signal compliance. Pedestrians were classified as younger or older, based on visual estimation of age.

Table 1. Total pedestrian observations by signal type.

Signal type	Younger pedestrians	Older pedestrians
Traditional pedestrian signals	1,949	658
Pedestrian countdown signals	2,203	779
Total, all areas	4,152	1,437

Walking Speeds

The project team measured the crossing distance at each crosswalk from the edge of the curb in the middle of the marked crosswalk. This distance was considered the crossing distance at each intersection. The trained observers viewed the videos and used a stopwatch to determine the crossing time for each pedestrian. This was the time for the pedestrian to leave the curb on one side and reach the curb on the other side. Measurements of pedestrians with discernable vision or mobility impairments were identified, although they were not grouped by age.

Start-Up Time

Pedestrians who approached the intersection during the steady DON'T WALK interval and waited for the WALK interval were observed to determine their start-up lost time. This is the time from when the WALK indication is displayed on the pedestrian signal until the pedestrian leaves the curb and starts his or her crossing. This start-up time is related to the pedestrian's reaction to the signal timing. Only pedestrians who arrived prior to the onset of the WALK interval were included in this analysis.

Signal Compliance

The project team recorded pedestrian compliance to the pedestrian signal indication. Trained observers recorded the number of pedestrians entering the intersection during the WALK, flashing DON'T WALK, and steady DON'T WALK indication during two hours of peak vehicle activity.

PEDESTRIAN SURVEYS

A pedestrian survey (provided in Appendix B of the full technical report) was developed to gauge pedestrian preference for signal type and to determine if pedestrians understood the meaning of the PCD signals. Pedestrians were intercepted after they completed their crossing at countdown-equipped intersections and asked if they would like to participate in a brief survey on pedestrian safety. Pedestrians were asked if they noticed anything different about crossing at this intersection than at similar intersections. A follow-up question confirmed that the difference noted was the countdown signal. All surveyed pedestrians were asked to explain the meaning of the countdown indication and if they had a preference regarding types of pedestrian signals (whether they preferred TPS or PCD signals).

EFFECT OF DIFFERENT WALKING SPEEDS ON PEDESTRIAN CLEARANCE TIMES

Study Intersection Selection Process

In each jurisdiction, the project team worked with the local engineering staff and local AAA representatives(s) to select four intersections to be used in the study—two intersections equipped with PCD signals and two intersections equipped with TPS. The local engineering staff was asked to provide a list of approximately 20 intersections in the jurisdiction that had significant pedestrian activity. Other criteria that were considered included:

- Pedestrian volumes, particularly older pedestrian volumes
- Lack of any construction or other temporary impediments (such as street closures) that may affect pedestrian behavior
- Ability to sufficiently collect data
- Surrounding land use
- Comparability in walking environment at intersections
- Intersections that may have been operating “at or close to capacity.” This was considered to explore the effect on capacity of increasing the pedestrian interval (by using a slower walking speed)
- Pedestrian signal timing parameters

Based on the above criteria, one of the four intersections also was selected to be a case study intersection. In the case studies, the WALK time and pedestrian clearance interval were compared to the available green time for walking speeds of 4.00, 3.50 and 3.00 feet/second to assess whether or not the intersection could accommodate each respective speed without modifying other signal operational parameters.

INTERSECTION OPERATIONS ANALYSIS

The CORSIM traffic simulation software package was used for analyzing intersection operations. CORSIM simulates traffic operations based on a user-specified street network that details roadway geometry, lane use, traffic control devices, traffic volumes, and turning movements. The simulation of traffic operations is used to determine the extent to which the amount of time allocated for pedestrian intervals affects traffic operations at each intersection.

In each jurisdiction, one intersection was selected for a case study. Simulations were developed for each case study location to reflect existing or observed conditions. Simulated output measures of effectiveness (MOEs), in particular, average delay per vehicle (ADPV) entering the intersection, were obtained from CORSIM and used to make quantitative assessments of the traffic impacts of changing pedestrian walking speeds. The ADPV (in seconds) was used to assign a level of service (LOS) to the intersection and its approaches.

LOS is a qualitative measure used to describe the operational condition of an intersection. LOS utilizes a rating system ranging from A to F, with A signifying the highest LOS, characterized by insignificant vehicular delay, and F signifying the lowest LOS, characterized by excessive vehicular delay. By definition, an intersection operating at its capacity is operating at LOS E. The relationship between vehicular delay and LOS at signalized intersections is shown in Table 2.

Table 2. LOS at signalized intersections (*Highway Capacity Manual 2000*).

LOS	Control delay (seconds per vehicle)
A	≤ 10.0
B	10.1–20.0
C	20.1–35.0
D	35.1–55.0
E	55.1–80.0
F	≥ 80.0

RESULTS

LITERATURE REVIEW

Pedestrian Walking Speeds

Walking speed is important for calculating pedestrian intervals at intersections. The reviewed studies clearly agreed that older pedestrians had slower walking speeds than their younger counterparts. However, the empirical data on the walking speeds of older pedestrians varied greatly among the studies.

Major findings included the following:

- Older pedestrians had slower walking speeds than their younger counterparts. The mean walking speed (MWS) for older pedestrians varied among the studies from 3.19 feet/second (ft./sec.) to 4.60 ft./sec. The 15th-percentile walking speed for older pedestrians varied from 2.20 ft./sec. to 4.00 ft./sec. For comparison, MWS for younger pedestrians varied among the studies from 4.42 ft./sec. to 4.96 ft./sec., and the 15th-percentile walking speed for younger pedestrians varied from 3.31 ft./sec. to 4.21 ft./sec.
- Fitzpatrick, Brewer, and Turner found that the 15th-percentile walking speed was 3.03 ft./sec. and 3.77 ft./sec., respectively, for older and younger pedestrians. The authors defined older pedestrians as persons older than 60 and younger pedestrians as persons under age 60. This study found a statistical difference in walking speeds between older and younger pedestrians. This study included 2,445 pedestrians at 42 sites in seven states (Fitzpatrick, Brewer, and Turner August 2005).
- Gates, Noyce, Bill, and Van Ee found that pedestrians older than 65 had a 15th-percentile walking speed of 3.02 ft./sec. Fewer than half of the older pedestrians observed in the study would be accommodated by traffic signals with pedestrian clearance intervals (PCIs) timed for walking speeds of 4.00 ft./sec. (Gates et al. 2006).
- Knoblauch found that the 15th-percentile walking speed was 3.19 ft./sec. and 3.08 ft./sec., respectively, when considering all older pedestrians and only those older persons who complied with the pedestrian signal (Knoblauch et al. 1995).
- The City of Berkeley, California conducted a study to evaluate potential impacts of new PCD signals on pedestrian behavior. The study concluded that overall pedestrian speed was 4.60 ft./sec. and 4.80 ft./sec. for traditional and countdown signals, respectively (City of Berkeley Office of Transportation).

Table 3 summarizes the walking speeds from empirical studies within the literature based on age, traffic control condition, and pedestrian signal type. Following that are the highlights of the literature review findings on pedestrian walking speeds with respect to older and younger persons.

Table 3. Summary of empirical data on walking speeds.

Researcher	Condition	Older pedestrians		Younger pedestrians		All pedestrians	
		Walking speed (ft./sec.)					
		Mean	15th-percentile	Mean	15th-percentile	Mean	15th-percentile
Knoblauch et al. (study includes 2,081 young and 2,379 old pedestrians)	Age-only	4.11	3.19	4.95	4.09		
	Older pedestrians who entered on WALK	3.94	3.08				
	Younger pedestrians who entered on WALK			4.79	3.97		
	Road width (28–42 ft.)	3.73	2.97	4.73	3.90		
	Road width (43–51 ft.)	4.01	3.16	4.77	4.01		
	Road width (52–104 ft.)	4.18	3.31	4.88	4.06		
Fitzpatrick, Brewer, and Turner (TCRP D-08/ NCHRP 3-71)	Study included 42 study sites in 7 states; 2,441 pedestrians	4.25	3.03		3.77	4.74	3.70
	Median refuge present/not present					4.87	4.80
Akcelik & Associates (2001, Australia)	Pedestrian mid-block signalized crossings on four-lane undivided roads					4.70	4.00
Bowman and Vecellio	Age	3.40		4.46			
Coffin and Morrall	Two signalized intersections	4.50/ 4.60	4.00				
	Signalized, actuated mid-block crossings	4.10/ 4.00	3.30				

Table 3. Summary of empirical data on walking speeds.
(continued)

Researcher	Condition	Older pedestrians		Younger pedestrians		All pedestrians	
		Walking speed (ft./sec.)					
		Mean	15th-percentile	Mean	15th-percentile	Mean	15th-percentile
Gates,	Age	3.81	3.02			4.6	3.78
Noyce, Bill, and Van Ee	Traffic control condition: signalized intersection —WALK phase	3.87	3.24	4.52	3.91		
	Traffic control condition: signalized intersection —DON'T WALK phase	4.30	3.45	4.96	4.21		
	Traffic control condition: STOP-controlled intersection	3.66	2.75	4.63	3.99		
Rouphail et al. (1998 <i>Highway Capacity Manual</i>)	Facility where there are greater than 20 percent older pedestrians						3.77
1982 <i>Traffic Engineering Handbook</i>			3.30				
City of Los Angeles, California unpublished study (DOT)	Age		3.82				
Guerrier and Jolbois (1998)	Age	3.19	2.20	4.42	3.31		3.09
City of Berkeley, California pedestrian signal countdown signal study	TPS					4.60	
	PCD signal					4.80	
Range		3.19–4.60	2.20–4.00	4.42–4.96	3.31–4.21	4.60–4.87	3.09–4.80

Researcher Recommendations on Pedestrian Walking Speeds

Table 4 summarizes specific recommendations for walking speeds from various researchers. Several of the key recommendations concerning pedestrian walking speeds are described below:

- Coffin and Morrall suggested using design walking speeds of 3.30 ft./sec. for elderly pedestrians at signalized pedestrian-actuated mid-block crosswalks and 4.00 ft./sec. for elderly pedestrians at signalized intersections. At signalized intersections near seniors or nursing homes, they suggested using a walking speed of 3.30 ft./sec. (Coffin and Morrall 1995).
- Rouphail et al. recommended a pedestrian crosswalk walking speed value of 3.90 ft./sec. for most conditions, except in areas with large numbers of older pedestrians. The number of older pedestrians is considered “large” when the elderly proportion begins to materially affect the overall speed distribution at the facility. It was found that the 15th-percentile walking speed for the overall population will drop to 3.77 ft./sec. when the elderly proportion increases to 20 percent. This study recommended the use of the lower 3.30 ft./sec. value when the percentage of elderly using the facility in question exceeds 20 percent (*Highway Capacity Manual* 2000).
- Gates, Noyce, Bill, and Van Ee recommended using a walking speed of 3.80 ft./sec. for locations with normal demographics and walking speeds of 3.60 ft./sec., 3.50 ft./sec., 3.40 ft./sec., and 3.30 ft./sec. at intersections where the proportion of older pedestrians exceeds 20, 30, 40, and 50 percent of pedestrians, respectively. At intersections where nearly all of the pedestrians can be classified as “older pedestrians,” the authors recommended using a walking speed of 2.90 ft./sec. (Gates et al. 2006).
- Fitzpatrick, Brewer, and Turner, in TCRP D-08/NCHRP 3-71, recommended the following: 3.50 ft./sec. for the general population and 3.00 ft./sec. for the older or less able population (Fitzpatrick, Brewer, and Turner August 2005).

Table 4. Summary of researcher recommendations on pedestrian walking speeds.

Researcher	Condition	Older pedestrians	All pedestrians
		Walking speed recommendations (ft./sec.)	
Knoblauch et al. (study includes 2,081 young and 2,379 old pedestrians)	Age-only	3.00	
Fitzpatrick, Brewer, and Turner (TCRP D-08/ NCHRP 3-71)	Study included 42 study sites in 7 states; 2,441 pedestrians		3.50
Coffin and Morrall	Two signalized intersections	4.00	
	Signalized intersections near seniors or nursing homes	3.30	
	Signalized. actuated mid-block crossings	3.30	
Rouphail et al. (1998 <i>Highway Capacity Manual</i>)	Facility where there are greater than 20 percent older pedestrians	3.30	3.90
Gates, Noyce, Bill, and Van Ee	Age	3.60 (20 percent > age 65) 3.50 (30 percent > age 65) 3.40 (40 percent > age 65) 3.30 (50 percent > age 65) 2.90 (100 percent > age 65)	3.80
2001 <i>Traffic Control Devices Handbook</i>	Where walking speeds slower than a normal rate of 4.0 ft./sec. are known to occur frequently and resources do not exist to undertake studies to establish a 15th-percentile speed	3.50	3.90
LaPlante and Kaeser	Minimum (curb-to-curb) for determining the pedestrian clearance interval; for use in accessibility guidelines	3.00	
	Use across the total crossing distance (top of ramp to far curb) for the entire WALK plus pedestrian clearance signal phasing	3.50	
Zegeer et al. (<i>Pedestrian Facilities User Guide</i>)	Population type; age	3.50	
Staplin, Lococo, Byington, and Harkey (<i>Guidelines and Recommendations to Accommodate Older Drivers and Pedestrians</i>)	Recommended due to older pedestrians' shorter stride, slower gait, and exaggerated start-up time	2.80	
Range		2.80–4.00	3.50–3.90

WEB-BASED AGENCY SURVEY

The agency survey conducted as part of this project was used to identify the criteria and/or policies jurisdictions may use when deciding whether to procure a pedestrian countdown (PCD) signal. The study found that two significantly different policies exist. First, many agencies will selectively install PCD signals based on a number of engineering judgment factors or criteria. The second policy is to replace all traditional pedestrian signals (TPS) and require new pedestrian signals to be replaced with PCD indications.

For those jurisdictions making selective procurement decisions for PCDs, the following factors are considered:

- Locations including school zones; downtown or urban areas; along pedestrian access routes or near pedestrian activity centers; areas where there are a significant number of senior citizens; and areas adjacent to transit stops or subway stations.
- Areas where there are high concentrations of :
 - o Pedestrians
 - o Seniors
 - o Very young and/or inexperienced pedestrians
 - o Pedestrian crashes
 - o Ethnic diversity
 - o Pedestrian pushbutton usage
 - o Bicycle volumes

Representatives of the following jurisdictions reported using specific criteria and/or guidelines.

Monroe County, New York

Monroe County, New York recommends the following guidelines for the placement of countdown pedestrian signals:

- PCD devices are recommended for longer crossing lengths where crossing time variance is greatest. A suggested threshold is at least 60 ft. of crossing distance.
- PCD devices are recommended where right-turning and left-turning volumes that conflict with the crosswalk are high. A suggested threshold is a combined 400 vehicles per hour (adding the conflicting right-turning and left-turning vehicle volumes together).

City Of Oakland, California

Policies. Action 1.2.7. Consider using crossing enhancement technologies like PCD signals at the highest pedestrian volume locations (City of Oakland, California Pedestrian Master Plan).

City of Sacramento, California Pedestrian Safety Guidelines

Countdown signals are useful:

- At locations with crossing distances greater than 60 ft. and PCIs greater than 15 sec.
- For high pedestrian volume
- At wide streets with long clearance intervals, the countdown signal effectively communicates the amount of time left to cross the street. At wide streets with medians, there should be adequate crossing time for the pedestrian to traverse the entire distance, and countdown signals should be used as a default.
- At actuated pedestrian signals, an additional, accessible pedestrian pushbutton should be located in the median. The countdown signal and median pushbutton should be used together wherever possible (City of Sacramento, California Pedestrian Safety Guidelines).

City of Monterey, California

Guidelines were outlined for the future implementation of pedestrian signal countdown devices. The following situations would justify the use of this device:

- Any crosswalk requiring a clearance interval of more than 15 sec.
- The following circumstances may justify the use of signal countdowns even if the interval is less than 15 sec.:
 - o High pedestrian volume
 - o High levels of vehicular traffic presenting a hazardous pedestrian crossing
 - o High percentage of pedestrians with walking disabilities and/or senior citizens, for example, near health centers, hospitals, and retirement communities
 - o School zones (City of Monterey, California Pedestrian Countdown Signal Guidelines)

State of Utah

Example guidelines. Given that the feedback on PCD signals has been positive, continue to install them at signalized intersections.

- If it is necessary to prioritize, give top priority to recurrent and fatal pedestrian-vehicle crash sites. The sites are a subset of all signalized intersections in Utah; selected sites tended to have either high severity scores (fatalities or serious injuries) or more than seven pedestrian-vehicle crashes.
- Give second priority to signalized intersections along recurrent pedestrian-vehicle crash corridors.
- Give third priority to signalized intersections that feature regular pedestrian activity.
- Consider a policy that incorporates PCD signals into all new traffic signals (Cottrell and Sichun).

OBSERVATIONAL STUDY OF PEDESTRIANS

Table 5 provides the combined results of 15th-percentile walking speeds for the six jurisdictions included in this study for traditional and PCD signals. The 15th-percentile walking speed represents the slower pedestrians at the intersection. The highlights of the study's findings include:

- The 15th-percentile speed for younger pedestrians varied from 4.10 ft./sec. to 4.60 ft./sec. at TPS and similarly from 4.10 ft./sec. to 4.70 ft./sec. at PCD signals.
- The 15th-percentile speed for older pedestrians varied from 3.40 ft./sec. to 3.80 ft./sec. at TPS and similarly from 3.40 ft./sec. to 4.00 ft./sec. at PCD signals.
- Based on the combined approaches in each jurisdiction, a clearance interval based upon a walking speed of 4.00 ft./sec. would accommodate the 15th-percentile walking speed of younger pedestrians but would not accommodate the 15th-percentile older pedestrians.
- A clearance interval based upon a walking speed of 3.50 ft./sec. would accommodate most but not all of the 15th-percentile older pedestrians in all jurisdictions surveyed. However, with sufficient WALK time, older pedestrians leaving the curb at the start of the WALK interval would be accommodated.
- A minimum of 3.40 ft./sec. would be needed to accommodate the 15th-percentile walking speed for the TPS and PCD signal in all jurisdictions observed.

Table 5. Combined results of 15th-percentile walking speeds.

Jurisdiction	15th-percentile walking speed for younger pedestrians (ft./sec.)		15th-percentile walking speed for older pedestrians (ft./sec.)	
	Traditional	Countdown	Traditional	Countdown
Broward County, Florida	4.40	4.30	3.80	3.40
Minneapolis/St. Paul, Minnesota	4.20	4.40	3.40	3.70
Montgomery County, Maryland	4.60	4.60	3.60	3.50
Orange County, California	4.10	4.70	3.60	4.00
Salt Lake City, Utah	4.30	4.70	3.40	3.50
White Plains, New York	4.20	4.10	3.50	3.60
Range	4.10–4.60	4.10–4.70	3.40–3.80	3.40–4.00

INTERSECTION OPERATIONS ANALYSIS

Number of Approaches or Crosswalks Where Total Pedestrian WALK Plus Clearance Time Exceeded Available Green Time at Each Case Study Intersection

As shown in Table 6, 19 crosswalks were analyzed. The number in parentheses next to each jurisdiction is the number of pedestrian crosswalks at the case study intersection.

Note that the peak-hour traffic volumes and pedestrian signal timing parameters (the peak-hour traffic volumes collected for the analyses were collected in 2004 and 2005) used for pedestrian signal timing evaluation and microsimulation modeling should be viewed as snapshots in time and are not necessarily representative of current conditions. This is because traffic volumes change over time; time-of-day volume characteristics change; and traffic signal timing parameters are modified by traffic engineers on a continuous basis, among other factors.

On a macro level, Table 6 shows that 13, 7, and 7 pedestrian crosswalks (of the 19 crosswalks studied) for the 3.00 ft./sec., 3.50 ft./sec., and 4.00 ft./sec. walking speed scenarios, respectively, exceeded the available green time at case study intersections.

Two definitions are important to understanding the data analysis and interpretations herein: the concept of pedestrian clearance time and the concept of available or maximum green time.

- The available green time is the maximum time that can be allotted to the pedestrian signal interval based on existing signal timings and phasing. The available green represents the green intervals for the parallel streets. The available green times do not add up to the cycle length because of time allotted to exclusive phasing for turn movements, concurrent phasing for approaches on the same street (such as northbound and southbound approaches), and yellow and red intervals.
- The pedestrian clearance time (PCT) is the time provided for a pedestrian crossing in a crosswalk, after leaving the curb or shoulder, to travel to the far side of the traveled way or to a

median. PCT is calculated by dividing the length of the crosswalk by the crossing speed. The total time allotted for a pedestrian to completely traverse a crosswalk is the sum of PCT and WALK time. A 7-sec. WALK time was used as recommended in the 2003 edition of the *Manual on Uniform Traffic Control Devices* (MUTCD) for all but one case study intersection where data were available. For the case study intersection in Minneapolis, Minnesota, a 12-sec. WALK time was required by agency policy for use in calculating total pedestrian WALK time.

Table 6. Number of approaches/crosswalks where total pedestrian signal time requirements exceeded available green time.

Jurisdiction	Walking speed (ft./sec.)		
	3.00	3.50	4.00
Broward County, Florida (3)	1	0	0
Minneapolis, Minnesota (4)	4	0	0
Montgomery County, Maryland (4)	4	3	3
White Plains, New York (4)	0	0	0
Salt Lake City, Utah (4)	4	4	4

Key findings related to PCT durations for the case study intersections included the following:

- The pedestrian intervals did not exceed the available green time for any crosswalk and/or WALK time scenarios at the White Plains, New York case study intersection.
- The pedestrian intervals exceeded the available green times for the 3.00 ft./sec. scenario in one of three crosswalks at the Broward County, Florida case study intersection and in four of four crosswalks at the Minneapolis, Minnesota; Montgomery County, Maryland; and Salt Lake City, Utah case study intersections.
- The pedestrian intervals exceeded the available green times for both the 3.50 ft./sec. and the 4.00 ft./sec. scenarios in three of four crosswalks at the case study intersections in Montgomery County, Maryland and in four of four crosswalks in Salt Lake City, Utah.

Table 7 provides an example for understanding the detailed data for each pedestrian crosswalk at each case study intersection. The “☒” symbol in the table indicates where the total pedestrian signal time exceeded the available green time. As shown in Table 7, the southbound approach (north crosswalk) had an available green time of 34 sec.

A walking speed of 4.00 ft./sec. yields a pedestrian interval of 32 sec. A walking speed of 3.50 ft./sec. yields a pedestrian interval of 34 sec. Because this is less than or equal to the available green time (34 sec.), the pedestrian interval for this approach can be serviced adequately during the time available without taking time from other phases.

A walking speed of 3.00 ft./sec. results in a required time for the pedestrian interval that is greater than the available green time (38 sec. versus 34 sec.). In this case, the available green could be increased to meet the time required for the pedestrian interval; however, this action potentially could take time away from other movements served by other phases. Consequently, this may increase

vehicular delay depending upon traffic volumes. The intersection operations impact analysis, presented in the next section, shows that increases in the available green time will result in greater delay for the major street approaches.

For this case study intersection, the pedestrian interval exceeded the available green time only for the 3.00 ft./sec. scenario. If the city of Minneapolis, Minnesota used the 2003 MUTCD recommendation of a 7-sec. (minimum) WALK time instead of the policy-based 12-sec. time, the available green time would be adequate at the 3.00 ft./sec. scenario. The city's use of a greater minimum WALK time interval in this case implies a proactive policy to provide greater LOS to pedestrians.

Table 7. Pedestrian WALK and clearance time durations for case study intersection in Minneapolis, Minnesota.

Approach/ crosswalk	Length (ft.)	Clearance time			Clearance time with 12-sec. WALK [total pedestrian time]			Available green (sec.)
		3.00 ft./ sec.	3.50 ft./ sec.	4.00 ft./ sec.	3.00 ft./ sec.	3.50 ft./ sec.	4.00 ft./ sec.	
Northbound/ south	75	25	21	19	37☒	33	31	34
Southbound/ north	78	26	22	20	38☒	34	32	34
Eastbound/ west	3	18	15	13	30☒	27	25	28
Westbound/ east	50	17	14	13	29☒	26	25	28

INTERSECTION OPERATIONS ANALYSIS

The purpose of this analysis was to determine the impact of various walking speeds on intersection operations. The analysis considered the effects on LOS (see Table 2) by changing the walking speed of pedestrians from 4.00 ft./sec. to a slower value and, thereby, increasing the pedestrian interval. The following criteria were developed to relate intersection LOS and delay impacts with various walking speeds. The results of this analysis are summarized in Table 8.

- Insignificant
 - o No change in LOS
 - o An increase in vehicular delay greater than 0.0 sec. and less than or equal to 2.0 sec.
- Minor
 - o No more than one change in LOS designation (for example, from B to C)
 - o An increase in vehicular delay greater than 2.0 sec. and less than or equal to 8.0 sec.

- Moderate
 - o No more than two changes in LOS designation (for example, from B to D)
 - o An increase in vehicular delay greater than 8.0 sec. and less than or equal to 15.0 sec.
- Major
 - o Intersection may have a degradation of three or more LOS designations (for example, from B to E)
 - o An increase in vehicular delay greater than 15.0 sec.

Table 8 shows the descriptive effect on the change in vehicular delay for each LOS for walking speeds of 3.50 ft./sec. and 3.00 ft./sec. In general, lowering pedestrian walking speeds to 3.5 ft./sec. or 3.00 ft./sec. at intersections that operate at LOS A, B, or C would result in insignificant to minor increases in overall vehicular delay at the intersections. However, using a walking speed of 3.50 ft./sec. at intersections that operate at LOS D or E would cause minor to moderate increases in overall vehicular delay at the intersections. Using a walking speed of 3.00 ft./sec. at intersections that operate at LOS D or E would cause moderate to major increases in vehicular delay at the intersections.

Table 8. Increase in vehicular delay at intersections operating with LOS A to F due to changes in walking speed (WALK interval and flashing DON'T WALK interval).

Walking speed	LOS					
	A	B	C	D	E	F
3.50 ft./sec.	Insignificant	Insignificant	Insignificant	Minor	Minor to moderate	Major
3.00 ft./sec.	Insignificant	Insignificant	Minor	Moderate	Major	Major

Furthermore, it was found that delay increased significantly when pedestrian times approached or exceeded the available minimum green times for the concurrent phase. This occurred most often on the major street approaches, which tended to be wider and, thus, had longer crossing distances resulting in a greater increase in PCI.

This phenomenon was examined more closely by comparing the effects of varying walking speeds on the major and minor approaches to an intersection. According to the data, increased vehicle delays at intersections with reduced walking speeds primarily were due to delays on the major street approaches.

Intersections with a slightly higher LOS in the base condition (such as Florida and Utah) showed a more uniform increase in delay for each walking speed.

The case study intersections in Minnesota, Maryland, and California were found to show exponential increases in average vehicle delay for the 3.00 ft./sec. scenario. The California case study also exhibited exponential increases in delay for the 3.50 ft./sec. scenario. The data indicated that the increased delay for all these case studies was due to increases in delay on the major street approaches.

DISCUSSION

SIGNIFICANCE OF THIS STUDY'S FINDINGS FOR CURRENT PRACTICE

Overall, the results of this study support the proposed National Committee on Uniform Traffic Control Devices (NCUTCD) guidance for reducing overall pedestrian walking speeds for use in pedestrian signal timing from 4.00 feet/second (ft./sec.) to 3.50 ft./sec. In the jurisdictions studied, this clearly would be beneficial for older pedestrians and, in many cases, could be accommodated without causing significant increases in vehicular delay.

1. Based on the results observed in each jurisdiction, a walking speed of 4.00 feet/second (ft./sec.) would accommodate a pedestrian walking at the 15th-percentile walking speed for younger pedestrians in all jurisdictions studied.
2. A walking speed of 4.00 ft./sec. also would accommodate a pedestrian walking at the mean speed observed for older pedestrians in all of the jurisdictions studied but would not accommodate a 15th-percentile older pedestrian in any of the jurisdictions studied.
3. A walking speed of 3.50 ft./sec. still would not accommodate the 15th-percentile older pedestrian in all jurisdictions studied. However, at all intersections in this study, if the signal timing provided a 7-sec. WALK and a change interval based on 3.50 ft./sec., older pedestrians with walking speeds at the 15th-percentile of older pedestrians would be able to cross the intersection provided they left the curb within 3.00 sec. of the start of the WALK interval.
4. Modifying pedestrian signal timing to accommodate a 7-sec. WALK interval and a pedestrian clearance interval based on a walking speed of 3.50 ft./sec. should be feasible with minimal operational impacts.
5. Intersection delay can be expected to increase significantly when the total time for the pedestrian interval approaches or exceeds the available green times for the concurrent vehicular traffic phase. This occurs most often on the major street approaches, which tend to be longer.
6. Walking speeds of 3.00 ft./sec. also may potentially be accommodated by increasing traffic signal cycle lengths. This, however, may have negative impacts on pedestrians; shorter cycle lengths are preferred for pedestrian traffic so that wait time is shorter. Furthermore, extending cycle lengths may have detrimental effects on the surrounding roadway network if signals are coordinated. A coordinated traffic signal typically would have to remain coordinated to maintain operational efficiency. Therefore, the entire signal coordination system would require modification, which may be costly and may affect traffic patterns.

NEXT STEPS

The next revision to the *Manual on Uniform Traffic Control Devices* (MUTCD) is currently slated for 2009. Prior to the revision, the Federal Highway Administration (FHWA) will prepare a Notice of Proposed Amendments, inclusive of changes to pedestrian walking speed provisions. Additionally, FHWA will consider recommendations from the NCUTCD. Proposed NCUTCD recommendations pertaining to pedestrian signal timing are shown in Table 9.

This study supports the proposed NCUTCD guidance for reducing overall pedestrian walking speeds to 3.50 ft./sec. It is important to note that the proposed guidance includes options to increase or decrease the pedestrian walking speed based on specific pedestrian characteristics and available pedestrian signal hardware at intersections.

There is a need for guidance regarding when to use pedestrian countdown (PCD) signals. This current study focused on a few communities that have developed criteria for implementing PCD signals.

The scope of this study did not specifically investigate the impact of signal timing on blind, low-vision, or otherwise disabled pedestrians and their use of pedestrian-accessible signals. Future studies should convene focus groups to develop parameters of future efforts that would consider the start-up time and walking speed differences of these pedestrian subgroups.

Table 9. NCUTCD recommendations for MUTCD Section 4E.10.

<p>GUIDANCE</p> <ul style="list-style-type: none"> ∞ Pedestrian clearance time is to start at the end of the WALK signal indication rather than during the WALK signal indication. ∞ Walking speed would be reduced from 4.00 ft./sec. to 3.50 ft./sec.
<p>OPTION</p> <ul style="list-style-type: none"> ∞ An option would be available to use 4.00 ft./sec. to evaluate the sufficiency of the pedestrian clearance time if there is equipment at the intersection such as extended pushbutton press or passive pedestrian detection for slower pedestrians to request a longer clearance time.
<p>GUIDANCE</p> <ul style="list-style-type: none"> ∞ Additional guidance is provided that indicates that a walking speed for pedestrian clearance time of less than 3.50 ft./sec. should be used if pedestrians who use wheelchairs routinely use the crosswalk or pedestrians routinely walk less than 3.50 ft./sec.
<p>GUIDANCE</p> <ul style="list-style-type: none"> ∞ This new provision provides guidance that would request that traffic engineers use a walking speed of 3.00 ft./sec. to calculate the WALK interval plus the PCI under the following conditions: <ul style="list-style-type: none"> ○ Start the calculation when the person is detected by a pedestrian detector or, if no detector is present, from a location 6 ft. back from the face of the curb or from the edge of the pavement at the beginning of the WALK signal indication; and ○ End the calculation of WALK time when the pedestrian has reached the far side of the traveled way being crossed. ∞ If the total crossing time calculated using the 3.00 ft./sec. guidance is longer than the sum of the PCI (as calculated using 3.50 ft./sec.) and the WALK interval, the WALK interval should be increased. ∞ For most applications on streets that are less than 100 ft. wide, WALK time plus pedestrian clearance time (as calculated using 3.50 ft./sec.) will meet or exceed the recommended total crossing time, especially when pedestrian detectors are located near the ramp and curb.

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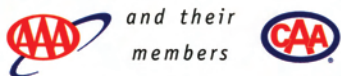
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